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Technical Report 408

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THE INFLUENCE OF LEARNING STRATEGIES IN THE ACQUISITION, RETENTION, AND TRANSFER OF A PROCEDURAL TASK

Robert N. Singer, Susan Ridsdale, and Gene G. Korienek
Florida State University

PERSONNEL AND TRAINING RESEARCH LABORATORY

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In order to analyze the effectiveness of various learner strategies upon initial learning, retention, and subsequent transfer of a motor skill, 50 college-age subjects were randomly assigned to one of five strategy conditions: imagery, chunking, verbalization, informed-choice, and control. For the task, a serial manipulation apparatus required participants to manipulate a predetermined sequence of buttons and switches. Following learning trials, [illegible]

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administered in order to discern the generalizability of specific strategies. Separate analyses for errors by positions, total errors, and total time revealed that imagers performed better on both acquisition and transfer than the chunking, verbalization, or informed-choice groups.

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Motor Skill Development
and Retention

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FOREWORD

The Personnel and Training Research Laboratory of the Army Research Institute for the Behavioral and Social Sciences (ARI) conducts research to support training methods to optimize skill acquisition and retention. A variety of research is being conducted on the effects of various learning strategies on skill acquisition and retention. ARI, in cooperation with the Defense Advanced Research Projects Agency (DARPA), is especially interested in training strategies for acquisition, retention, and transfer of motor skills. This report discusses the learning, retention, and transfer effectiveness of several different learning strategies for a procedural task involving sequential motor responses.

Research was conducted at Florida State University under contract MDA903-77-C-0020, which was monitored by Joseph S. Ward of ARI under Army Project 2Q161102B74F and funded by DARPA.

JOSEPH ZEIDNER
Technical Director

THE INFLUENCE OF LEARNING STRATEGIES IN THE ACQUISITION, RETENTION, AND TRANSFER OF A PROCEDURAL TASK

BRIEF

Requirement:

To analyze and compare the effectiveness of different learner strategies on learning a sequential procedural motor skill task, as part of an investigation on training and retention of motor skills.

Procedure:

A computer-managed task apparatus provided a variety of control switches which had to be manipulated in a predetermined sequence. Five learning strategies were randomly assigned among 40 college-age participants: (1) imagery, with instructions to use mental pictures to remember the response sequence; (2) chunking, with instructions to remember responses in groups of three; (3) rote verbalization, with instructions to name each response aloud while moving each switch; (4) informed choice, with instructions on all three strategies and free choice to use any or none; and (5) control, with no strategy instructions.

Each participant performed two familiarization and two practice trials, then eight acquisition trials; after a short rest, a one-trial retention test, a 2-minute break, and an eight-trial transfer task requiring a different set of responses.

Findings:

Significant learning occurred during the trials, as shown by a marked decrease in both time and errors from trial 1 to trial 8. Also, significantly more errors were made in the middle of a sequence than at the beginning or end (position effect). The informed-choice group made the fewest errors during the acquisition trials, but the imagery group made fewest errors during the transfer trials and consistently took the least time to finish. That the control group ranked second or third throughout, however, suggests the participants had fairly effective preexisting learning strategies.

Utilization of Findings:

Basic research on how people learn to perform complex sequential motor actions contributes to the development of more effective training of many military skills.

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THE INFLUENCE OF LEARNING STRATEGIES IN THE ACQUISITION, RETENTION, AND TRANSFER OF A PROCEDURAL TASK.

INTRODUCTION

In recent years, researchers have shown an increased interest in the cognitive processes which may primarily influence the learning of various matter. This thrust, in turn, has generated numerous approaches to examine the effectiveness of a number of learner strategies to facilitate the acquisition and retention of verbal material. To a much lesser degree, the use of strategies within the motor learning domain has been of concern.

An effective learning strategy has been defined as the simplest and most efficient means of processing the information inherent in a situation (Newell & Simon, 1972). Rigney (1978) suggested that a strategy may be interpreted as signifying operations and procedures a learner may adopt to acquire, retain, and to retrieve different kinds of information. Similarly, Bruner, Goodnow, and Austin (1956) have written that a strategy provides the learner with a pattern of decisions for the acquisition, retention and future utilization of information. Based upon an interpretation of the preceding definitions, it would appear that a strategy, or [illegible] strategies, developed by the learner in [illegible] his/her cognitive abilities and situational demands, are effective in relating new information to previously obtained knowledge (Bruner, 1961).

Within the area of verbal learning, the use of learner strategies has facilitated the acquisition and retention of specific information across a variety of age groups (Belmont & Butterfield, 1971; Bruner, Goodnow, & Austin, 1956; Hagen, Hargrove, & Ross, 1973; Kingsley & Hagen, 1975). Various strategies such as mnemonics, encoding, rehearsal, and labeling have proven to be effective in the acquisition and retention of information for immediate recall. Typically, experiments involve the presentation of letter lists which must be committed to memory in order to be recalled immediately following presentation. The effectiveness of particular strategies is usually assessed by the length of interim pauses during list learning (Belmont & Butterfield, 1971) and correctness of response during serial recall (Maccoby & Hagen, 1965).

In order to ascertain the effectiveness of naming or labeling stimuli during acquisition on later recall, Atkinson, Hansen, & Bernbach (1964) devised a serial recall task. Picture cards were arranged in a horizontal line and displayed one at a time to the subject. After presentation, each card was returned face down. Once four to eight cards had been shown, a cue card was presented and the subject's task was to point to the card in the series that matched the cue card. Results indicated the subjects who used a labeling strategy were able

to recall a higher percentage of pictures correctly than control subjects. Additionally, the serial order recall was better for strategy groups than for non-strategy groups. Hagan and Kingsley (1968) developed a similar paradigm in which children 4, 6, 7, 8, and 10 years of age were tested in conditions where verbal naming was either required or not required. Results indicated that with middle-age group children, labeling facilitated learning while at the youngest and oldest levels, no change in recall occurred.

Researchers have demonstrated that concrete stimuli (i.e., pictures and designs) are more easily retained than abstract verbal material (Bevan & Steger, 1971; Paivio, 1969) and that imagery appears to be a more effective mnemonic than verbal labeling in paired associate tasks using concrete noun pairs (Paivio & Foth, 1970). Similarly, when learners are instructed to imagine a mental picture formed by specific word-pairs or to use a visual image (Bower & Winzenz, 1970; Paivio & Yuille, 1969) learning is enhanced.

Although particular strategies may be more adaptable to specific tasks, the general conclusions in studies designed to determine the effectiveness of learner strategies are unequivocal. The application of appropriate mental operations which are compatible with a learner's

cognitive capabilities leads to superior performance attainment as compared to individuals who do not utilize the same strategy operations.

Learning strategies can also facilitate the storage as well as retrieval of verbal information. Several types of strategies that have been shown to promote learning are the learner's free choice of mnemonic techniques, various encoding instructions, or instructions in the use of particular strategies (Craik & Lockhart, 1972; Craik & Tulving, 1975). Although the dependent measures differ, the conclusions drawn remain similar. Strategy usage has a facilitatory effect on the acquisition and retention of information.

The implication for motor learning would appear to be that the use of strategies should facilitate the learning process. However, while there exists an abundance of supportive evidence for strategy usage within the verbal learning area, research is severely lacking within the motor learning domain. Thus, inferences must be drawn from verbal learning research as to the potential beneficial effects of various types of strategies on the acquisition and retention of motor skills.

In an attempt to apply verbal labeling strategies to a motor task, Shea (1977) required subjects to reproduce a single criterion position on a manual lever

positioning apparatus after experiencing the movement once. Of the three groups tested, one group was provided with relevant labels, one group created its own irrelevant labels, and one group had no labels. The relevant label group showed significantly higher recall scores than either of the other two groups. Additionally, no decrement in recall was observed over time (60 sec) when relevant labels were provided. Such results lend credence to the notion that a meaningful labeling strategy enhances the storage of information as well as facilitating later recall.

Similarly, Housner and Hoffman (1979) investigated the role of imagery in the reproduction of criterion points and locations. Subjects were instructed to formulate a mental picture of their hands moving to the criterion position or at the end location point. During rest intervals, some subjects were required to employ imaginal rehearsal while others were prohibited from rehearsing by the use of distractor tasks. Results indicated that those subjects who applied the imagery [illegible] the movement to end location and also [illegible] intervals displayed superior recall of the criterion points. Similar results were reported by [illegible] (19[illegible]), who investigated the effectiveness of [illegible]

kinesthetic awareness on the learning of six serial positions in a curvilinear repositioning task. However, Hagenbeck required imagery subjects to mentally picture the criterion positions as analogous to the numbers of a clock face. Of the three strategy groups, imagery was found to be most effective during reproductive movements.

Ridsdale (1978) compared chunking, overt rehearsal, forced choice, and free choice strategies and their influence on subjects attempting to learn a card sorting task. The chunking strategy was shown to be more effective for skill acquisition while free-choice (self-generated) strategies yielded better performances in retention. It would appear from data such as these that particular strategies may be appropriate with particular types of people, e.g., a strategy X cognitive style arrangement. Whether or not such a notion is tenable remains open to speculation. However, the results of preliminary investigations on the effectiveness of strategies within the motor learning domain closely parallel verbal learning findings in that individuals who are guided in their use of strategies show superior performance in relation to control groups.

Although tasks of location reproduction and card sorting require both cognitive and motor capabilities, the demands of everyday life often require individuals to

perform motor skills of far greater complexity than these tasks. Additionally, they might have to transfer knowledges and skills to new learning situations. However, while the use of cognitive strategies has been shown to facilitate the acquisition and retention of newly learned material (e.g., Campione & Brown, 1974; Kendler, 1964; Kendler & Kendler, 1962), the generalizability (transfer) of these same strategies to different situational contexts is questionable.

Still, there are those (Gagné, 1977, Singer & Gerson, in press; Wichelgren, 1974; Wittrock, 1967) who contend that rather than being oriented to specific kinds of external content, such as language or numbers, cognitive strategies are and should be, largely independent of content and apply to all types of learning conditions.

As Gagné (1977) has pointed out, the difficulty lies in arranging conditions so that transfer can be demonstrated. Strategy transfer usually cannot occur unless the initial learning environment includes some reference to the transfer situation (Bransford, Franks, Morris, & Stein, 1978; Campione & Brown, 1974), such as the temporal structuring of the components within each task being similar (Keele & Summers, 1976). Campione and Brown (1974) suggested that transfer is best when the form of the two situations remains the same. More specifically,

context may well direct one's attention toward relevant facts. A familiar problem in a new context fails to elicit any strategy since nothing in the situation cues the learner how to approach the problem. Investigations dealing with elementary children (Campione, 1973) have provided additional evidence for the context-tied problem. To overcome this circumstance, Campione (1973) suggested that when individuals learn useful problem-solving strategies, these strategies should be employed in a variety of situations so that a particular strategy is not restricted to a specific context. It would appear, then, that strategies which enhance skill acquisition and retention also have the potential to transfer to the learning of a skill in a new situation with similar parameters.

Until recently, there has been a lack of research on the cognitive control an individual may exert over motor behavior. Although several motor behaviorists (e.g., Pew, 1974; Schmidt, 1975) have emphasized the importance of the study of processes which underlie motor skill acquisition, few investigators have actually examined the cognitive processes associated with the production of a motor response. Much of the work [illegible] on either the content of the input, [illegible] of specific output actions. Therefore, [illegible] exists [illegible]

accompany motor performance and (2) those strategies that will lead to enhanced retention of learned material and yet will also possess transfer potential for related learning tasks.

While previous efforts in the analysis of motor skill learning have been geared to relatively simple tasks which placed minimal demands on a learner's organizational and decision-making capabilities, the demands of everyday complex tasks require a learner to utilize more sophisticated cognitive processes. This is especially true with procedural tasks which involve a series of operations in a predesignated sequence. Such tasks require the accomplishment of a sequence of activities in order for satisfactory performance to occur. The procedure an individual follows to start an automobile may be viewed as a simplistic example of a procedural task. From the unlocking of the car door, to the foot pressure on the accelerator, a series of operations must be performed in the correct sequence in order for the goal to be attained.

Although few investigations have dealt with procedural tasks, results indicate that, unlike continuous tracking tasks, procedural tasks are prone to forgetting. However, practice (rehearsal) during retention intervals has been shown to reduce forgetting (Brown, Briggs, & Naylor, 1963). In a recent study involving the effectiveness

of three different training strategies upon initial learning, retention, and transfer, Johnson (1978) concluded that imagery strategies which require a learner to provide his or her own cueing and feedback from memory are effective in increasing the retention of procedural tasks.

Therefore, it was the purpose in the present study to analyze the effectiveness of specific strategies on the acquisition, retention, and subsequent transfer of a procedural task involving sequential motor responses. The following strategy conditions were investigated: imagery, chunking, rote verbalization, and informed choice.

In line with the consistent finding that strategy usage enhances initial learning, it was hypothesized that: subjects applying a particular strategy would display superior performance across all three conditions (acquisition, retention, and transfer) when compared to control subjects who employed no designated strategy.

While there exists little evidence to support the effectiveness of strategy usage for a procedural task, it would appear that either imagery or chunking (Housner & Hoffman, 1979; Ridsdale, 1978) would enable a learner to acquire initial skill more effectively. Therefore, it was hypothesized that during acquistion and retention

trials, subjects in the imagery and chunking groups would perform better than the rote verbalization group.

Although the potential for the transfer of strategies from one task to another is evident, relatively few investigations have dealt specifically with this area. However, it would appear that strategies that are compatible with the learner's cognitive style (Pask, 1975; Ridsdale, 1978) may be more amenable to transfer situations. More specifically, imposed strategies may enhance initial learning and retention, however, transfer situations require an individual to identify the existent similarities between tasks. Thus, a self-imposed strategy, consistent with the learner's cognitive style, may be more easily applied in transfer tasks. Therefore, it was hypothesized that subjects in the informed choice group would display a greater degree of transfer learning between the acquisition and transfer phase of the investigation.

METHODS

Subjects

Fifty male and female undergraduate and graduate students (*M* age = 20.74 yrs; *SD* = 3.50) from Florida State University volunteered to participate in this study.

Apparatus

The Serial Manipulation Apparatus (SMA) (cf. Singer, 1976) is a computer-managed task that engages two computer systems for operation. A Cyber 74 stores the software that is used to generate the control programs for the SMA, and an Imsai 8080 microprocessor actually controls program operation and data collection. Data recorded by the microprocessor are transmitted directly to the Cyber 74 for storage and future reference. The two systems are linked via an Astroset modem, and the communication interface is a Lear-Siegler ADM-3A terminal. A video monitor was also used to allow the experimenter full view of the subject and the apparatus (see Figures 1 and 2).

The hardware portion of the SMA is a wood and metal structure, with a horizontal platform situated at the table-top height. A rectangular encasement in the back of the SMA houses a Radio Shack TRS-80 video monitor that was used to display both visual instructions and knowledge of results to the subjects, and a Sony video monitor showed the same information to the experimenter. In addition, a loudspeaker was mounted above the apparatus and connected to a Panasonic RQ-415AS audio cassette tape player/recorder. The cassette player was used to provide taped instructions to subjects.

A number of response manipulanda are situated in

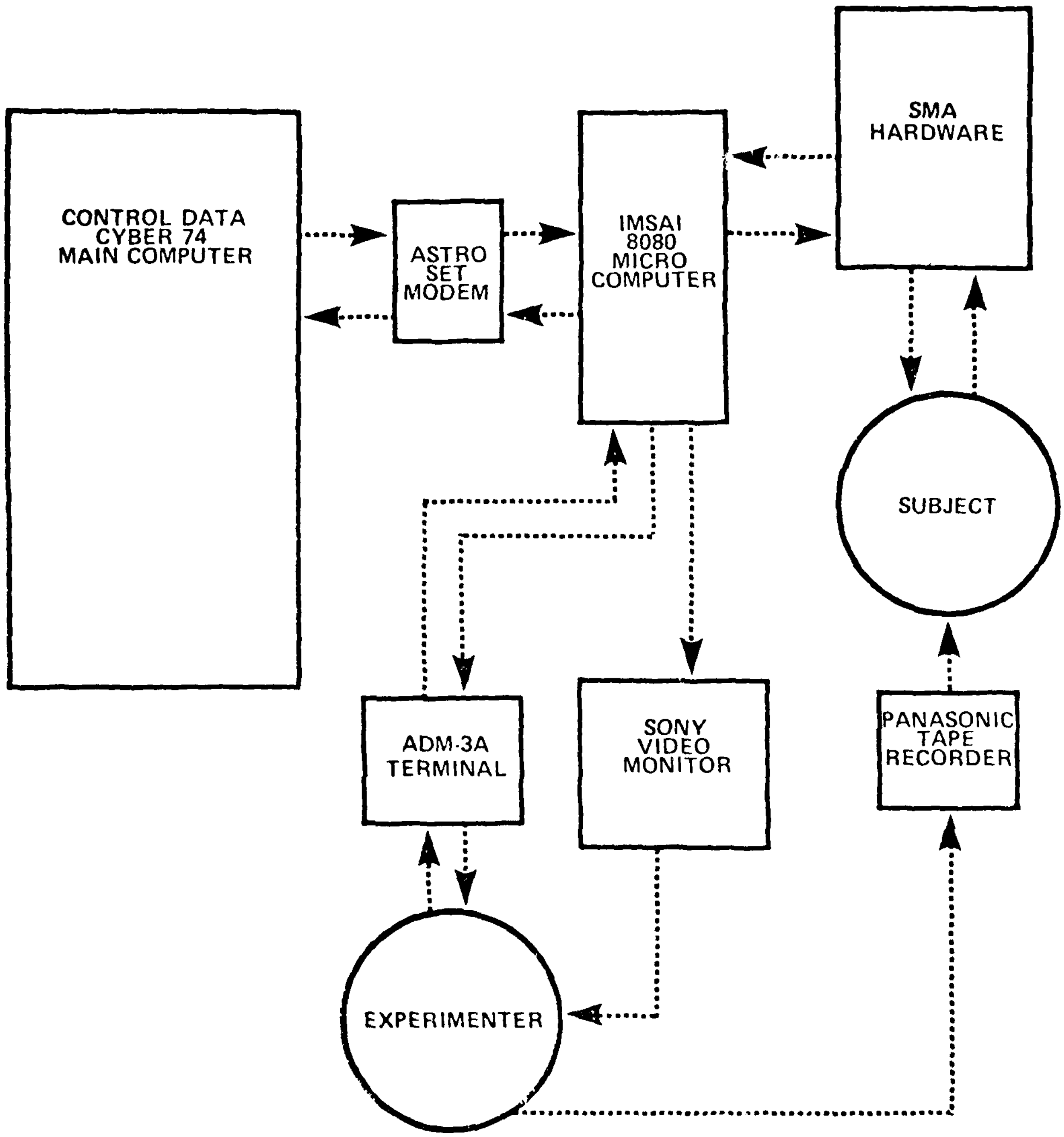

Figure 1. Diagram of the control system for the Serial Manipulation Apparatus.

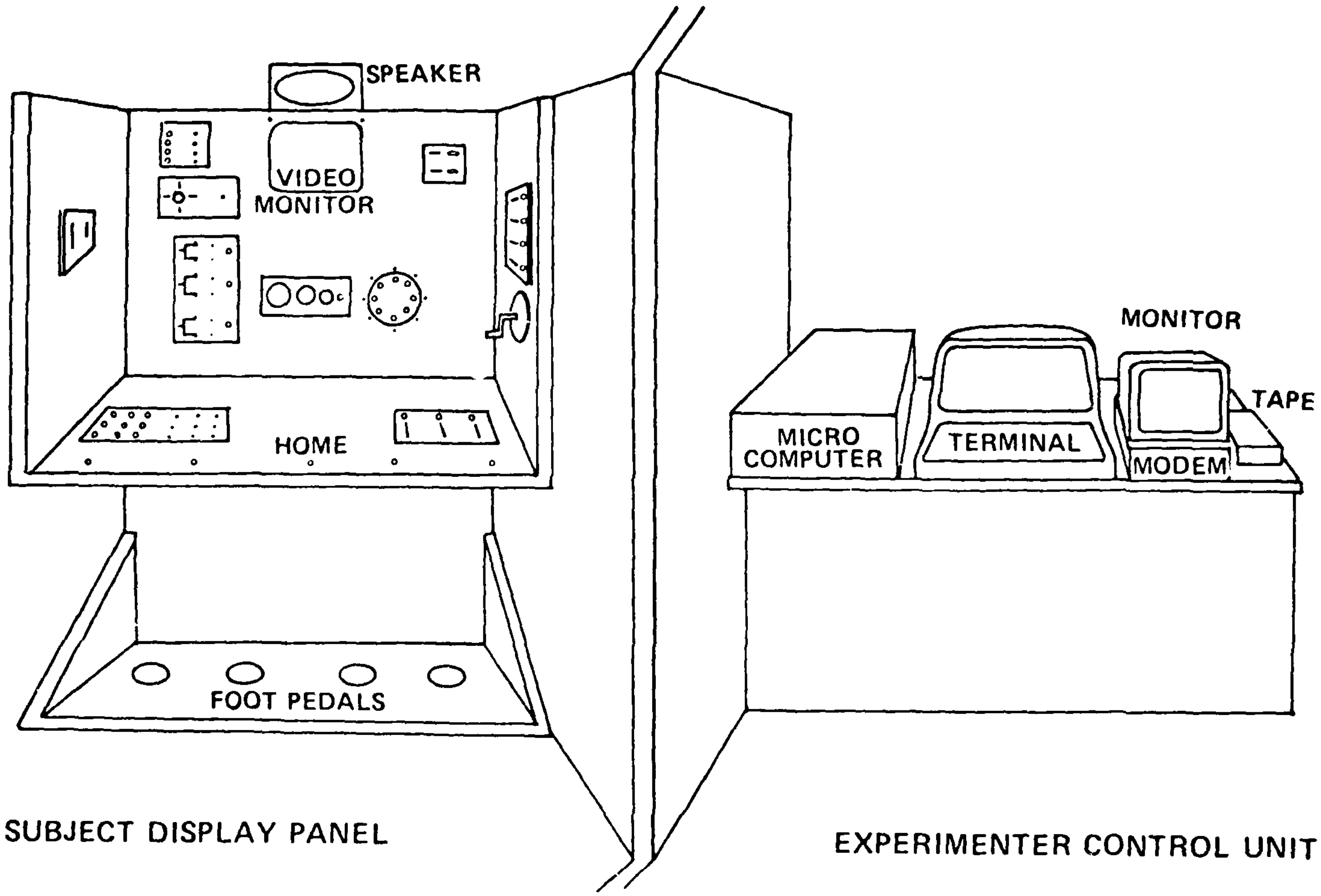

Figure 2. Diagram of physical arrangement of experimenter and subject displays.

various locations throughout the task display. These mechanisms are the same at each location point but differ from location to location. The response mechanisms consist of light switches and a crank located on the side panels of the SMA, and pushbutton microswitches, knife switches, pressure switches sensitive to touch, a rheostat, a probe-hole device, and a telephone dial at different locations on the back panel of the apparatus. The platform section has a simulated calculator keyboard of nine buttons mounted on the left side, and three toggle switches placed on the right side. A "home" button is situated in the center of this section and nearest the front edge. In the present study, the home button had to be depressed by a subject to initiate and terminate the response sequence. Finally, four foot pedals are located on the base of the SMA in a left-to-right manner.

Each response mechanism has a light emitting diode (LED) placed next to it which serves as an additional visual cue to subjects. The LED's for the foot pedals are located on the platform surface near the front edge and directly above their corresponding pedals. The LED's and the response mechanisms are housed in white metal boxes that protrude slightly from the various surfaces of the equipment. This ensures easy access to the switches and lights in case maintenance and repair work become

necessary.

In addition to the variety of responses required by the different locations, the SMA offers another fundamental attraction. A variable number of possible responses can be made at each choice point. For example, four light switches are located in a panel on the right side of the SMA, while nine alternatives are available in the simulated calculator keyboard. Three toggle switches and three knife switches provide an equivalent number of response alternatives. On the left side of the apparatus, only two light switches and two pressure buttons offer alternatives. The variability in the number of alternatives at each response location is deliberate, as this tends to increase the complexity of the skill.

In the present study, nine location points were selected from those available, and these had to be learned in a sequence. None were repeated during a trial.

Procedures

Subjects entered the test area individually and were randomly assigned a strategy condition. The strategy groups were: (1) imagery, with subjects [illegible] mentally picture storage bins in a warehouse [illegible] "place" each response mechanism into a [illegible]; (2) chunking, with subjects told to [illegible] into subsequences of three [illegible]

verbalization, with subjects required to repeat each stimulus aloud as the response was made; (4) informed choice, with subjects instructed in the use of the three previous strategies and then told to select one of them, a combination of them, or a strategy of their own; and (5) a control group, where subjects were not provided specific strategy instructions.

The subjects were seated in a chair in front of the SMA, facing the video monitor with the home button in a line that bisected the midline of the body. Specific taped task and strategy instructions were played for the subjects over the loudspeaker (see Appendix). In conjunction with the tape, visual directions appeared on the screen to ensure understanding of the task to be performed.

The subjects received two familiarization trials designed to acquaint them with the apparatus and subsequent procedure. On the first trial, the designated location point and the specific switch were displayed to the subject in two ways. A letter and a number appeared on the screen (i.e., B-2), and the LED next to the particular response mechanism lit up. There were five responses that had to be made to complete the sequence. On the second familiarization trial, the subject was required to repeat the same five locations

without the aid of the visual monitor or the LED's.

The familiarization trials, and all ensuing trials, were initiated when the subject pressed the home button. On the first familiarization trial and the first practice trial with all nine locations, both visual cues appeared and the subject responded appropriately. Immediately after a correct response was made, the second set of stimuli appeared. Following this correct response, the cues for the third response were activated. This procedure was repeated until all five switches had been correctly manipulated, at which time the subject was required to return to and depress the home button to terminate the response sequence.

When the home button was pressed at the end of the sequence, feedback information appeared on the screen. The information was the subject's reaction time, movement time, total response time, position errors, and total response errors for each trial. The subject viewed this information for 15 sec, and then the screen blanked for the 10 sec intertrial interval. The subject was now ready to begin the learning phase of the experiment.

Prior to engagement in the acquisition trials, the subjects received taped instructions on the use of the particular strategy that was randomly assigned to them. Following strategy instructions, they received two

practice trials with the same responses that were to be used during the actual learning phase. On these practice trials, subjects were cued as to the correct response through the video monitor and the LED next to each switch. The only difference between the familiarization and practice trials and all subsequent learning trials was that the latter trials required nine responses instead of five. However, the initiation and termination of all response sequences necessitated depressing the home button.

After the two practice trials, subjects performed eight acquisition trials from memory. No cues were available on the screen, nor were the LED's lit. The response sequence involved pressing the home button, manipulating nine mechanisms in the correct sequence, and returning to the home button. Depression of the home button at the end of each sequence caused the feedback information to appear on the screen. If the button was pushed in the middle of the sequence, or a mechanism was manipulated out of order, an "error" message flashed on the screen. The message remained there until the correct response was made. When all nine responses were made in the correct order, and the home button was pressed, one trial was completed.

Subjects were required to finish eight acquisition

trials, after which half the subjects in each strategy group rested during the intertrial interval and the 20-sec retention interval, while the other half performed a written addition task during the same time period. Following this interval, subjects performed the same sequence of responses with no external visual cues as a test of retention.

The retention test was followed by a 2-min rest interval, at which time subjects were questioned as to their use of a particular strategy. These verbal reports were recorded on a brief, specially constructed questionnaire. Upon completion of the rest interval, subjects undertook the transfer phase of the task.

The transfer phase differed from the acquisition phase in the following ways. Only one practice trial was given to subjects on which they were cued by the lights and the screen. The sequence of responses was changed, but nine sequential responses still constituted one trial. Finally, no retention was given but subjects were again questioned as to their use of strategies. See Figure 3 for a summary of the sequential procedures used in the study.

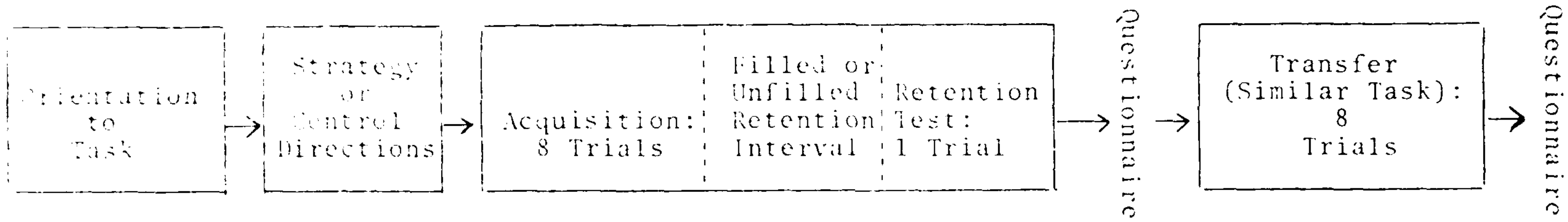

Figure 3. Sequential procedures in the experiment.

RESULTS

A 5 X 2 X 8 X 9 (strategies X test conditions X trials X positions) factorial ANOVA, with repeated measures on the last three factors, was conducted on response errors that occurred at each position. A significant trials effect, F (7, 315) = 37.96, $p < .01$ was obtained, and a Newman-Keuls follow-up test revealed that more errors were made on trial 1 than on any other trial. In addition, a greater number of response errors occurred on trials 2-5 than on trials 6-8. These means, as well as all subsequent significant effects, are presented in Table 1. The learning curve illustrating these data is found in Figure 4.

There was also a significant positions effect, F (8, 360) = 7.38, $p < .01$. Follow-up comparisons revealed that more errors were made at position 6 than at any other position. Additionally, both positions 4 and 5 resulted in more response errors than any other positions except 6 and 8, respectively. As can be seen in Figure 5, the greatest number of errors occurred at the middle positions, indicative of a primacy-recency effect. Thus, the performance curve across positions resembles the bow-shaped curve associated with the serial recall effect.

A significant test X strategies interaction, F (4, 45) = 3.11, $p < .05$, is depicted in Figure 6. Newman-Keuls

Table 1

Mean Scores of Significant Effects for Errors

Trials	1	2	3	4	5	6	7	8	
	36.37	36.94	21.49	12.94	9.80	7.16	6.39	5.46	
Positions	1	2	3	4	5	6	7	8	9
	5.29	13.83	10.63	22.49	20.35	21.78	13.43	19.23	15.39

Trials / Positions	1	2	3	4	5	6	7	8
1	13.60	11.70	6.50	2.90	4.20	2.30	.50	.60
2	51.70	16.30	18.90	9.40	5.70	2.20	5.20	1.20
3	20.70	17.20	18.80	10.30	7.10	3.50	4.00	3.40
4	45.50	38.90	33.30	15.40	12.90	12.60	11.40	9.70
5	46.00	36.00	32.80	15.20	12.90	4.90	7.30	7.70
6	49.20	47.80	21.20	14.30	14.00	13.20	7.20	7.30
7	25.70	18.40	14.20	17.00	8.30	8.20	8.20	7.40
8	36.40	27.40	26.20	21.40	14.60	12.10	10.80	4.90
9	38.50	28.80	21.50	10.60	8.50	5.40	2.90	6.90

Strategy / Test Conditions	Acquisition	Transfer
Imagery	22.97	7.17
Chunking	20.26	33.10
Verbalization	10.60	14.29
Inf. Choice	5.83	20.76
Control	12.50	10.69

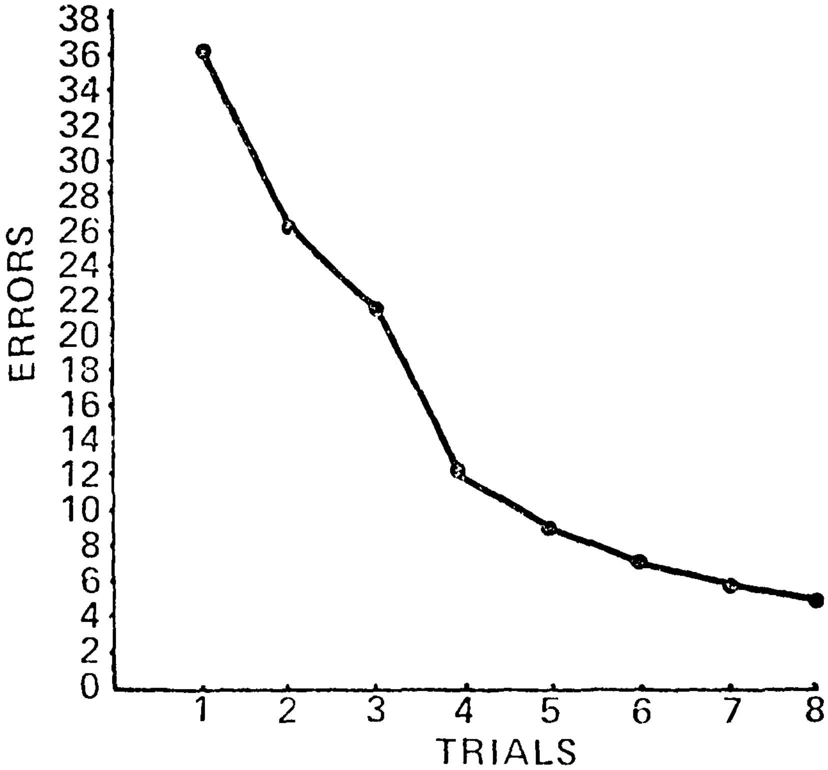

Figure 4. Trial to trial analysis of error scores by positions.

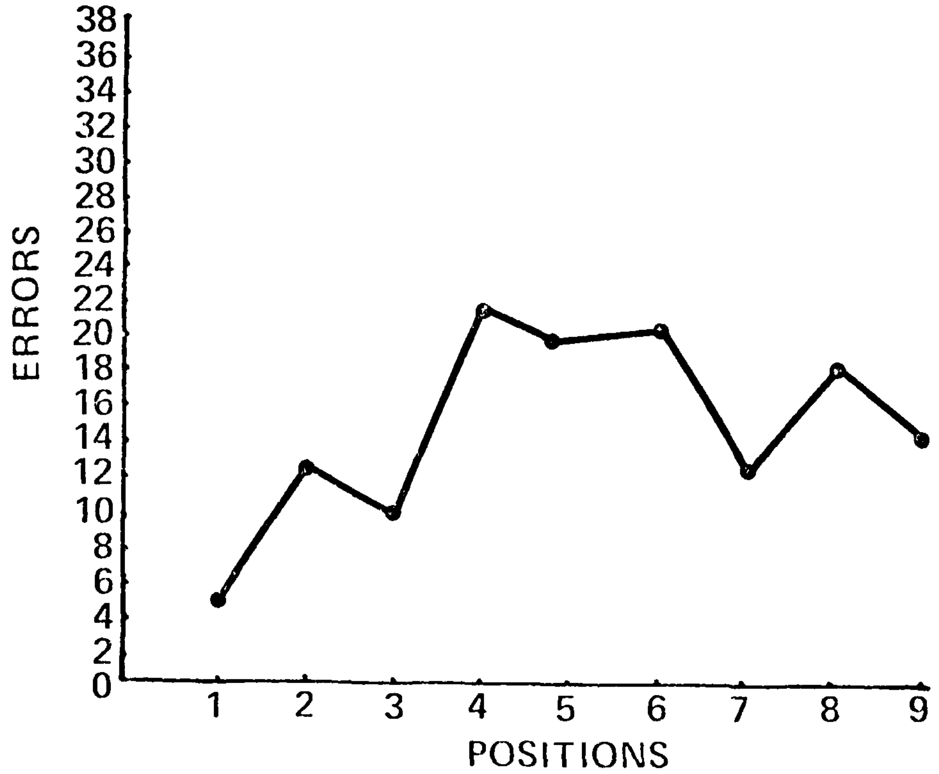

Figure 5. Errors made according to position of sub-task in each trial.

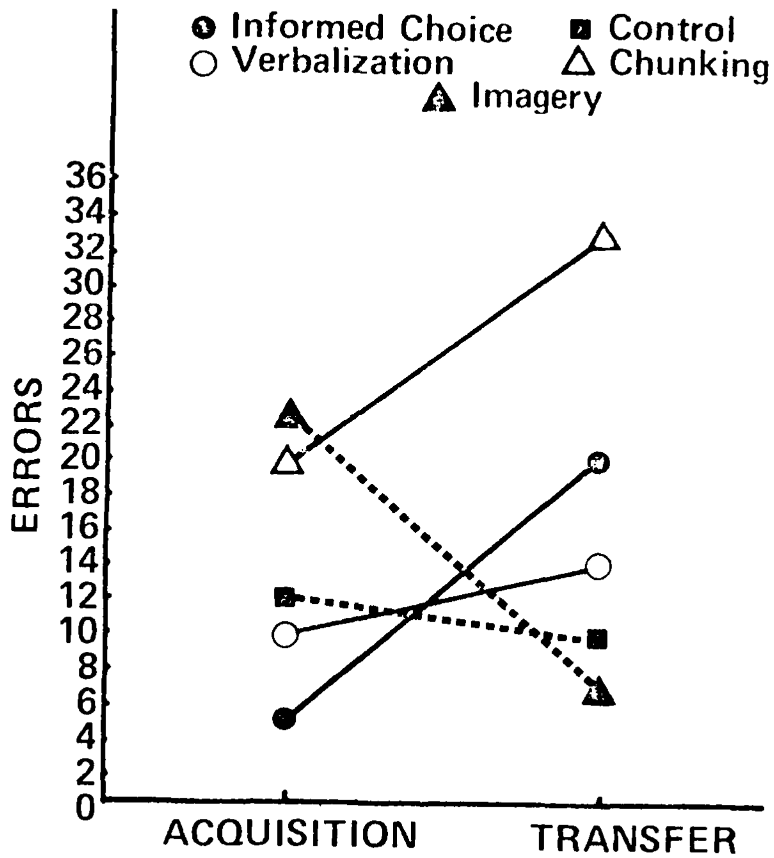

Figure 6. Acquisition of transfer phases compared as to errors made by strategy groups.

follow-up comparisons revealed that the imagery group had a greater number of errors than the informed choice group during acquisition. However, during the transfer phase, the imagery group made significantly less response errors than the chunking group.

A significant trials X positions interaction was the final effect revealed in this analysis, F (56, 2520) = 1.93, $p < .01$. As can be seen in Figure 7, more errors were made at position 2 on trial 1 than at any other position. During trial 2, more errors were evidenced at positions 4, 5, and 6 than on any other trial. Additionally, a learning effect can be discerned from the decrease in errors across trials.

A 5 X 2 X 8 (strategies X test conditions X trials) factorial ANOVA, with repeated measures on the last two factors, was conducted on the total errors made on each trial. A significant trials main effect, F (7, 315) = 36.97, $p < .01$ is depicted by the learning curve in Figure 8. Follow-up comparisons revealed that more errors were made on trial 1 than on trials 4-8. In addition, trials 4-8 were significantly different from each other. The mean scores for all significant effects appear in Table 2.

A significant test conditions X strategy interaction is shown in Figure 9, F (4, 45) = 3.10, $p < .05$. The

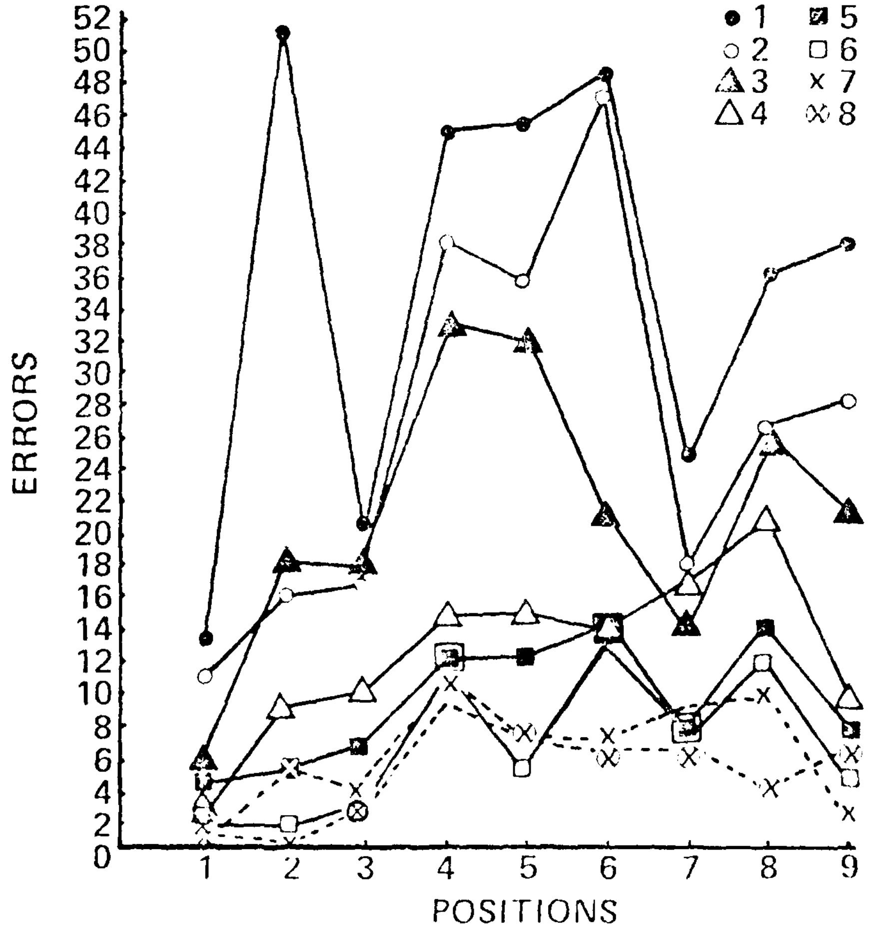

Figure 7. A trial by trial analysis of errors made at each sub-task position.

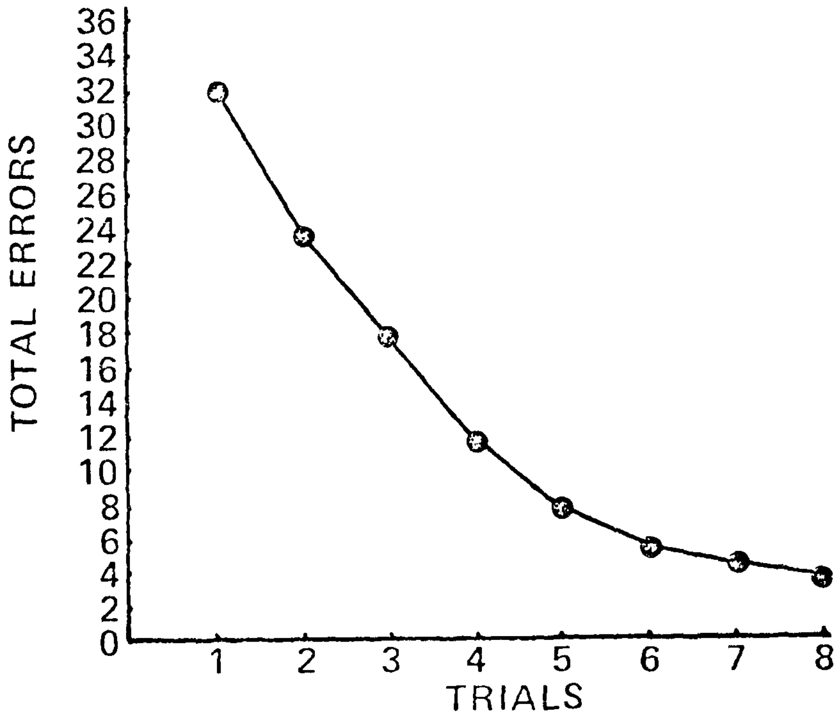

Figure 8. Total errors analyzed according to trials.

Table 2

Mean Scores of Significant Effects for Total Errors

Trials	1	2	3	4	5	6	7	8
	32.60	24.42	18.61	12.39	8.84	6.43	5.85	4.91

Test Conditions	Acquisition	Transfer
Strategy		
Imagery	20.70	6.45
Chunking	18.36	30.05
Verbalization	9.54	12.62
Inf. Choice	5.24	18.74
Control	11.25	9.63

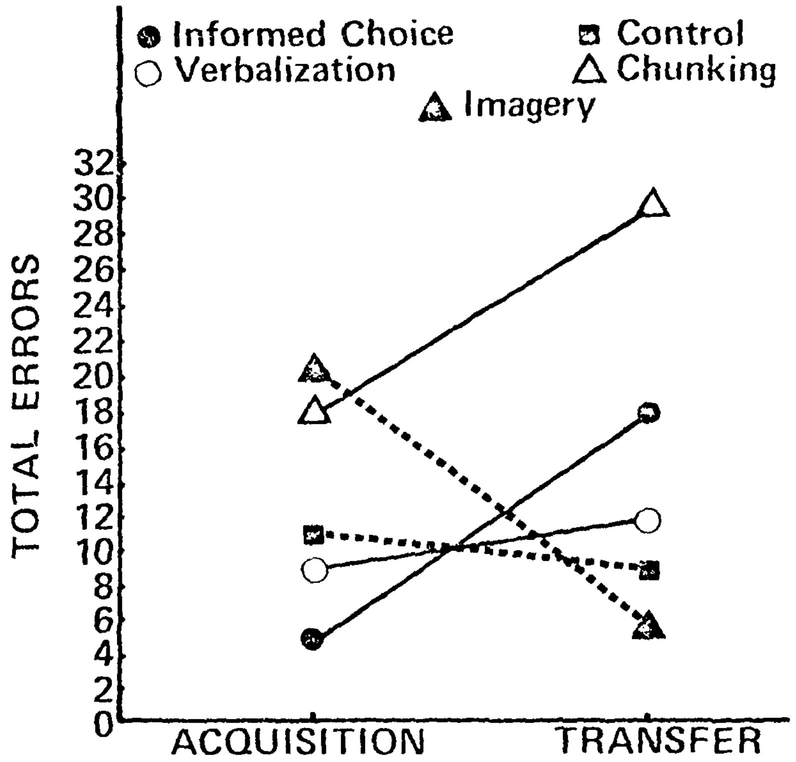

Figure 9. Total errors compared among groups between acquisition and transfer phases.

Newman-Keuls follow-up revealed that the chunking group made more errors than the imagery group during the transfer trials as compared to the acquisition trials.

A 5 X 2 X 2 (strategies X retention interval X trials) ANOVA conducted to determine retention, with total errors as the dependent measure, and a 5 X 2 X 2 X 8 (strategies X retention interval X trials X positions) ANOVA, with number of errors made at each position, failed to reveal any significant differences for the comparisons made.

The final dependent variable analyzed was time to task completion. A 5 X 2 X 8 (strategies X test conditions X trials) factorial ANOVA, with repeated measures on the last two factors, yielded two significant main effects and one significant interaction effect. The mean scores for all significant effects for Time appear in Table 3.

The significant trials effect, $\underline{F}$ (7, 315) = 57.81, $\underline{p} < .01$ is illustrated in Figure 10. Follow-up comparisons revealed that all trials were significantly different from each other with the exception of trials 5 and [illegible]. There was also a significant strategy effect, $\underline{F}$ [illegible] = 2.77, $\underline{p} < .05$. As can be seen in Figure 11, the imagery group took the least time to complete the task, while the chunking group took longest for task completion.

The significant strategy X trials interaction is

Table 3

Mean Scores of Significant Effects for Time (in sec)

Strategy	Imagery	Chunking	Verbalization	Inf. Choice	Control
	46.08	102.33	92.84	69.93	78.48

Trials	1							
	193.97	148.79	90.72	61.90	43.33	31.18	29.90	23.67

Strategy	Imagery	Chunking	Verbalization	Inf. Choice	Control
Trials					
1	116.07	209.52	249.25	182.61	199.46
2	74.37	175.19	242.77	119.37	151.92
3	53.27	146.43	86.61	68.08	121.19
4	34.10	92.54	61.36	57.69	47.55
5	31.02	59.78	31.71	45.28	43.25
6	24.40	50.12	22.47	28.77	29.64
7	15.91	43.95	29.39	36.78	30.79
8	19.55	41.09	19.20	20.84	22.24

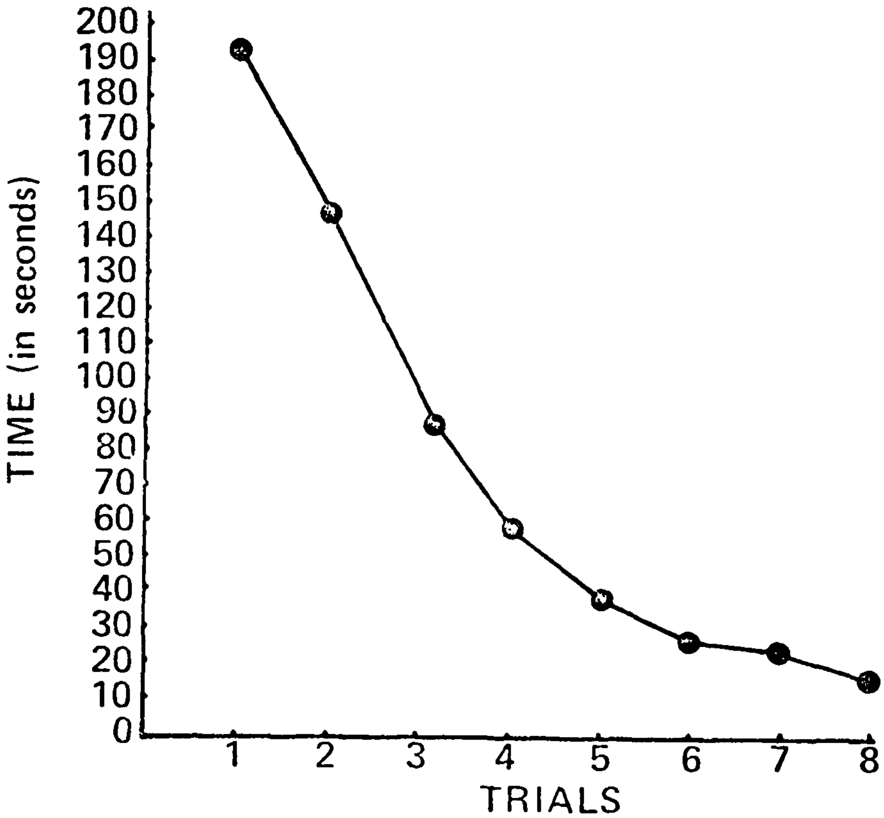

Figure 10. Analysis of time to complete task each trial.

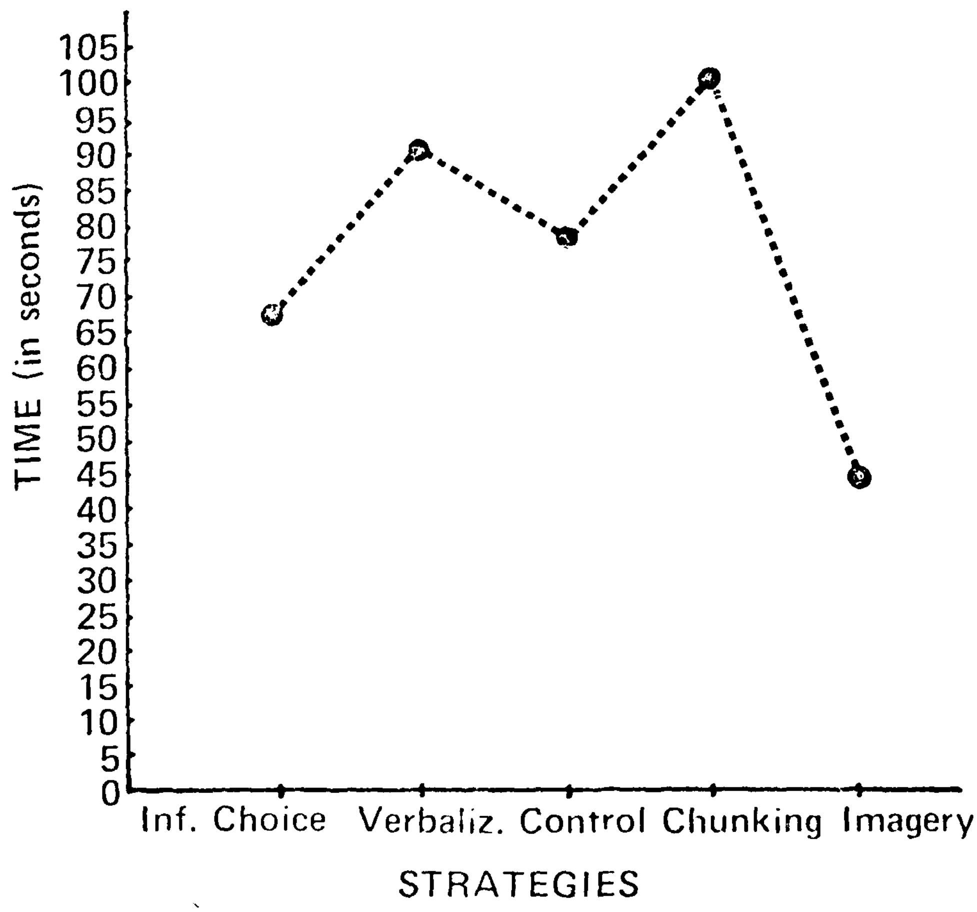

Figure 11. Groups compared as to time to complete task.

depicted in Figure 12, F (28, 315) = 2.06, $p < .01$. The Newman-Keuls follow-up comparisons revealed that the control group took longer to complete the task than the imagery group on all trials except trial 8. Similarly, the control group spent more time on the task than the informed choice group on all trials with the exception of trials 7 and 8. Additionally, the imagery group took less time to complete the task than the chunking group on all trials and less time than the verbalization group on all trials with the exception of trials 5, 6, and 8. The chunking group, however, took longer to complete the task than the verbalization group on trials 5 through 8.

A 5 X 2 X 2 ANOVA with time as the dependent variable during the retention interval, failed to indicate any significant differences among the groups.

DISCUSSION

The significant reduction in both total errors and time to complete the task are clearly indicative of a general learning effect. Similarly, the primacy-recency effect manifested by a greater number of errors at the middle positions, is consistent with reported results within the verbal learning literature (Murdock, 1962).

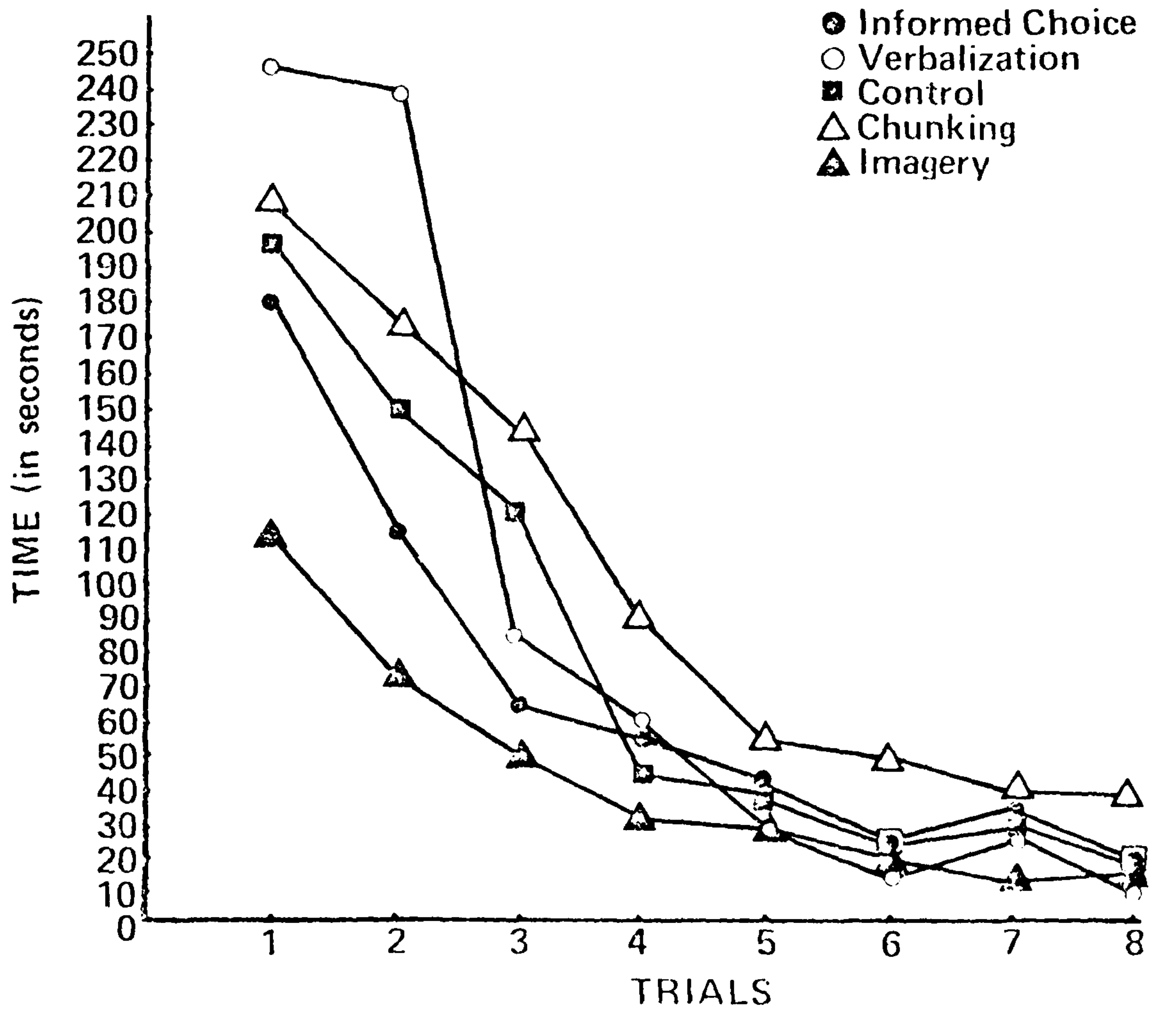

Figure 12. Groups compared as to time to complete task each trial.

However, the increase in errors between acquisition and transfer evidenced by three of the strategy groups is explained less easily.

While various imposed strategies may increase the rate of initial skill acquisition (Singer & Pease, 1976), the same strategies may not facilitate learning in transfer situations (Singer & Gaines, 1975). In line with this view, it has been suggested that, in certain situations, imposed strategies may be in competition with preexistant strategies within the learner's repertoire (Pask, 1975). This notion would appear to lend credence to the superior performance of the control group in both acquisition and transfer phases of the present investigation. Since the subjects in the control group were given no strategy instructions, it may be logically assumed that they incorporated (self-generated) a strategy consistent with their own cognitive styles. In addition, questionnaire data administered after both acquisition and retention trials revealed that subjects in the control group consistently employed the same strategy across both acquisition and transfer tasks. However, subjects in the chunking, verbalization and informed choice groups reported that they changed strategies during both acquisition and transfer phases. Thus, the poorer performance on the transfer task may have been due to the subject's

inability or lack of desire to consistently apply a single strategy.

An alternative explanation for the obvious lack of strategy transfer may be due to the similarity of the acquisition and transfer tasks. Within the realm of verbal learning, serial recall of items has been shown to be affected by "similarity interference" (Watkins, Watkins, Craik, & Mazuryk, 1973). In this sense, the results of the present experiment reflect the possible presence of retroactive inhibition.

Retroactive inhibition refers to the detrimental effect of recently acquired material upon previously learned material. In this sense, both the acquisition and transfer tasks required subjects to remember 9 different locations. In addition, with the exception of one location, all positions, as well as all directional changes, were identical in both acquisition and transfer tasks. To the extent that approximately 2 min separated acquisition from transfer phases, it is not surprising that interference may have occurred.

The fact that the imagery group demonstrated superior performance during the transfer task lends particular credence to the effectiveness of strategy generalizability. However, questionnaire results revealed that in addition to imaging location, imagery subjects also emphasized the

sequence within positions. It would appear that although other strategy groups may have learned the locations of the sequence, the particular sequence of individual switches and buttons was not committed to memory. Such an explanation would appear to account for the greater number of errors exhibited by these groups.

Results of the present investigation are reflective of an obvious need to emphasize the learning of a strategy before application is required (Singer, Gerson, & Ridsdale, in press). In this sense, strategy instruction must be sufficient in communication to enable the learner to fully comprehend its usage. Perhaps when this occurs, the true potential value of learning strategies as an aid in skill acquisition and transfer, as speculated elsewhere (Singer, 1978; Singer, Gerson, & Ridsdale, 1978; Singer & Gerson, in press) will be realized.

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APPENDIX A: INSTRUCTIONS TO SUBJECTS

GENERAL DIRECTIONS: SMA

The device in front of you is the Serial Manipulation Apparatus. It requires you to manipulate several switches or push several buttons in the proper order. You will be informed of that order by a display of the letter and number of the switch that will appear on the screen in front of you and lights that will appear next to the switches or buttons on the device. When the light appears you are to push the button or throw the switch next to the light. Do not push the light. Your task is to learn the sequence and to go through it as rapidly and with as few errors as possible.

To begin the sequence there will be a cue on the screen that will tell you to press down and hold the home button. Use the index finger of your preferred hand only. The home button is located directly in front of you. After you press that button, a few seconds later a cue will appear and a light corresponding to a particular switch will go on next to that switch. There will be three switches in this sequence. Move to that switch and flip it. Then, a second cue will appear on the screen, as well

as a light next to another switch. You will also move to that switch and flip it. You will then be cued to move to a third switch. After you finish that you will return to the home button and press it.

Feedback information will then appear on the screen for you. I will explain that to you when it appears. You are now ready to begin the practice trial by pressing the home button. Remember, there are only three responses in this sequence. Now, press and hold the home button and wait for your cue (pause 5 seconds).

You see before you the feedback information concerning how well you performed. The fourth line of numbers is the total time it took you to go through the sequence. Below that you see error counts. The first line tells you the number of errors you made in each position. You have to regard the first three positions in this case. On the rest of the trials you will receive shortly, consider only the first nine positions, one for each switch in the sequence. Below that is the total number of errors you made for the sequence. You are now ready to begin the learning trials. You will receive two practice trials in which you will be [illegible] [illegible] the switches. [illegible] Remember that [illegible] sequence, return to the home button. The directions to

return home will not appear on the screen. When your feedback appears it will only be shown for 10 seconds, which is a shorter time than you just had to view it. Are you ready?

IMAGERY STRATEGY: SMA

I am going to inform you of a technique that should improve your ability to learn this task. It is called imagery. This is a strategy where you imagine that the display in front of you is divided into many compartments which contain all the switches in all the units. In other words, it is like a storage bin, with different kinds of compartments. As you make a response, imagine that you are actually placing something into a particular compartment. Continue to do this in your mind with each switch that you manipulate. As you respond, you should be trying to remember certain storage areas on the display and their relation to one another. By mentally rehearsing the sequence in terms of storage areas during practice trials and free periods, as well as applying this technique during the performance trials, your performance should be aided. Now place your index finger on the home button as indicated on the screen and follow directions.

CHUNKING STRATEGY: SMA

I am going to inform you of a technique that should improve your ability to learn this task, it is called chunking. This is a strategy by which you attempt to group individual switches into blocks of threes in order to remember them. In other words, as you take the two practice trials and the eight learning trials, do not attempt to remember where each correct switch was located in isolation. Rather, since you have nine switch locations to remember, try to combine them into groups of three. After each trial, you will receive free time in which to rehearse your chunking strategy before the next trial begins. By chunking the responses into groups of three during each 10 second free period following feedback information, as well as during the trials, your performance should be aided. Now, please place your finger on the home button as indicated on the screen and follow directions.

VERBALIZATION STRATEGY: SMA

I am going to inform you of a technique that should improve your ability to learn this task. It is called verbalization. Verbalization is a strategy in which you repeat out loud the correct letter and number that is associated with each response. During the two practice trials, the letter and number information will appear on the screen in front of you. For example, if the first letter and number were to be B and 1, you would repeat out loud B-1 as you make the response. If the next response is C and 4, please say C-4 as you make that response. Follow this procedure throughout all the trials.

You will know which switch is associated with a particular letter and number as the red light will illuminate next to that switch. After your feedback is displayed, the screen will blank. At this time you should verbally rehearse the sequence before the next trial begins. By verbalizing during each free period as well as during the trials your performance should be aided. Notice the drawing below the screen. It represents the apparatus with the different locations and switches. Each location and switch is labeled with a letter and a number. Study them. (pause 10 seconds)

Now place your index finger on the home button, depress it, and follow directions.

MULTIPLE STRATEGIES: SMA

I am going to inform you of techniques that should improve your ability to learn this task. The first is called imagery. This is a strategy where you imagine that the display in front of you is divided into many compartments which contain all the switches and all the units. In other words, it is like a storage bin with different kinds of compartments. As you make a response, imagine that you are actually placing something into a particular compartment. Continue to do this in your mind with each switch that you manipulate. As you respond, you should try to remember certain storage areas on the display and their relation to one another. By mentally rehearsing the sequence in terms of storage areas during practice trials and free periods, as well as applying this technique during the eight performance trials, your performance should be aided.

Another technique that should improve your ability to learn this task is called chunking. This is a strategy by which you attempt to group individual switches into blocks of threes in order to remember them. In other words, as you take the two practice trials and the eight learning trials, do not attempt to remember where each correct switch was located in isolation. Rather, since you have nine switch locations to remember, try

to combine them into groups of three. After each trial, you will receive free time in which to rehearse your chunking strategy before the next trial begins. By chunking the responses into groups of three during each 10 second free period following feedback information as well as during the trials, your performance should be aided.

Yet another technique that should improve your ability to learn this task is called verbalization. Verbalization is a strategy in which you should repeat out loud the correct letter and number that is associated with each response. During the two practice trials, the letter and number information will appear on the screen in front of you. For instance, if the first letter and number were to be B and 1 you would repeat out loud B-1 as you make the response. If the next response is C and 4, please say C-4 as you make that response. Follow this procedure throughout all of the trials.

You will know which switch is associated with a particular letter and number as the red light will illuminate next to that switch. After your feedback is displayed, the screen will blank. At this time you should verbally rehearse the sequence before the next trial begins. By verbalizing during each free period as well as during the trials, your performance will be aided. Notice the drawing below the screen. It represents the

apparatus with the different locations and switches. Each location and switch is labelled with a letter and a number. Study them. (pause 10 seconds)

You have just been informed of three kinds of techniques that you might use to learn this task effectively: imagery, chunking, and verbalization. Feel free to use any one or combination of strategies that you wish or disregard all of them. Remember, a particular technique should help you learn the task. Now place your finger on the home button, depress it as indicated on the screen, and follow the directions.

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1 USAIMA, Ft Bragg, ATTN: Marquat Lib
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1 US WAC Ctr & Sch, Ft McClellan, ATTN: Tng Dir
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